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U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—BULLETIN No. 69.

GIFFORD PINCHOT, Forester.

IN COOPERATION WITH THE STATE OF CALIFORNIA.

FORESTRY & RANGE MANAGEMENT
COLORADO A & M COLLEGE
FORT COLLINS, COLORADO

SUGAR PINE AND WESTERN YELLOW PINE IN CALIFORNIA.

BY

ALBERT W. COOPER, M. F.,

Forest Inspector, Forest Service.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

FOREST SERVICE.

GIFFORD PINCHOT, *Forester.*

OVERTON W. PRICE, *Associate Forester.*

FOREST MANAGEMENT,
THOMAS H. SHERRARD, *in Charge.*

INSPECTION,
FREDERICK E. OLMSTED, *in Charge.*

DENDROLOGY,
GEORGE B. SUDWORTH, *in Charge.*

FOREST EXTENSION,
ERNEST A. STERLING, *in Charge.*

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WILLIAM L. HALL, *in Charge.*

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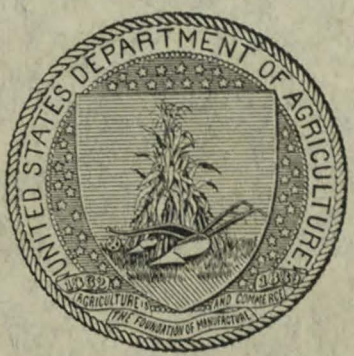

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., May 23, 1906.

SIR: I have the honor to transmit herewith a manuscript entitled "Sugar Pine and Western Yellow Pine in California," by Albert W. Cooper, Forest Inspector, Forest Service, in cooperation with the State of California, and to recommend its publication as Bulletin 69 of the Forest Service.

The four plates accompanying the manuscript are necessary for its proper illustration.

Respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SUGAR PINE AND WESTERN YELLOW PINE IN CALIFORNIA.

INTRODUCTION.

Since the early mining days in California, sugar pine has been one of the most valuable timber trees of the State, and the exhaustion of the eastern white pine forests has of late brought it into even greater prominence. Unfortunately, it has a somewhat restricted range, and the supply in sight, though large, is by no means unlimited. Yellow pine in California, which is of equal importance as a timber tree, is also included in this study. The two species are so intimately associated, both in the forest and in the market, that a study of one would be incomplete without a study of the other.

It is believed that the time is ripe for the better management of the forests of the State, since the growth of lumbering on a large scale, the increased value of timberlands, and, above all, the awakening interest of the lumbermen themselves, seem to indicate the possibility of a first step, at least, in this direction.

The object of the study here presented, therefore, is to devise modifications in present lumbering methods which may lead to a more conservative treatment of the yellow and sugar pine forests and to their better protection from fire.

RANGE AND DISTRIBUTION.

Within the State of California sugar pine and western yellow pine are closely allied in range, but their commercial and botanical ranges, as a whole, present the greatest divergence. The yellow pine is the most widely distributed tree of the West, comprising in its botanical range almost the whole of the Pacific and Rocky Mountains forest regions. The sugar pine, on the contrary, is limited to the States of Oregon and California. Its merchantable range is still more limited, being confined practically to the west side of the Sierra Nevadas and portions of the Coast Range.

Yellow pine is able to endure great variations in climate and to flourish under most unfavorable conditions. The sugar pine is far more fastidious, and unless the different factors of situation are favorable it is unable to exist. A brief review of the distribution of these two trees will show the difference in their adaptability.

The yellow pine ranges from the central part of British Columbia south and eastward to the Black Hills of South Dakota. It accommodates itself to the dry lava beds between the Rocky Mountains and the Pacific ranges, and sweeps in a wide path southward to the hot and dry mesas of Arizona and New Mexico. It grows on both the high, dry mountain ranges of Colorado and the high but well-watered mountains of California. Its southern range extends even into Lower California, where it forms fairly extensive forests on the San Rafael Mountains east of Todos Santos Bay, with an extreme southern boundary on the isolated peaks of San Pedro Marter.

In comparison with this broad range that of the sugar pine seems almost insignificant. It is limited to the Pacific mountains and occupies but a small portion of these. It is confined almost wholly to mountain slopes, ravines, and canyons in the more moist and protected regions. The northern boundary of its range is in the valley of the Santiam River in Marion County, Oreg., whence it extends southward along the Cascade and Coast ranges, bearing eastward to the headwaters of the Deschutes River and the western shores of Upper Klamath Lake. It reappears on the bluffs east of Klamath Lake and in Drew Valley to the westward of Goose Lake. Its range in California extends southward along the Coast Range to the vicinity of Clear Lake. It reappears again in the Santa Lucia Mountains in Monterey County. The main range of the tree, however, is along the west slope of the Sierra Nevadas, though it occasionally crosses the main divide and is found in scattered stands on the east slope. In southern California it is confined to the higher elevations. Its southern limit is with that of the yellow pine on Mount San Pedro Marter in Lower California.

There is often a marked relationship between the extension of a species southward and the altitude at which it will exist. This relationship is clearly shown in the case of sugar pine. In Oregon the sugar pine is found in merchantable quantities at elevations of 2,500 to 3,000 feet and descends to 1,000 feet near the coast. In northern California the tree occurs between 2,500 and 6,000 feet; in the central portion of the State, between 4,000 and 7,500 feet, and in the southern portion between 5,500 and 9,000 feet. Roughly speaking, the altitude of the botanical limits increases at a rate of 500 feet in every 200 miles southward.

The lower range of the yellow pine in California is approximately 1,000 feet below that of sugar pine. In the northern part of the State the upper range of sugar pine is about 1,000 feet above that of yellow pine. This difference between the upper limits of the two species holds throughout the greater part of the Sierras. But in southern California, in the San Jacinto Mountains, the difference greatly

decreases and almost disappears. This is no doubt due to the uniformly warm, dry climate, even at high altitudes, where cold nights are offset by warm days. Within the region of their joint occurrence sugar pine may be considered, therefore, a species of the higher elevations and yellow pine a species of the lower.

The merchantable range of yellow pine in California usually coincides with the botanical range of the sugar pine. Yellow pine, because of its greater ability to withstand drought, has an extensive range on the eastern side of the Sierra Nevada, where sugar pine is almost wholly lacking. Thus the two species, especially sugar pine, are very rarely found where the annual precipitation is less than 25 inches, and the region of best development for sugar pine is almost wholly within a belt where the average annual rainfall is at least 40 inches.

The region of best development of sugar pine extends along the west slope of the Sierras from Plumas County south to Kings River, in Fresno County. This may still further be limited to Eldorado, Tuolumne, Mariposa, and Madera counties, which are by far the heaviest producers of sugar-pine timber.

The region of best development of yellow pine is much more difficult to determine. As far as stand per acre is concerned, the nearly pure yellow-pine forests about the McCloud and Pitt River countries and on the Shasta Plateau might be considered the region of best development.[a] The tree individually perhaps reaches its maximum size on the basins of filled lakes on the western slopes of the central Sierras, but throughout this region it is so mixed with sugar pine, Douglas spruce, incense cedar, and fir that the stand of yellow pine per acre is comparatively light.

ASSOCIATED SPECIES.

As previously shown, the ranges of both sugar and yellow pine in California are much the same, although the actual distribution varies. The most common associate of sugar pine on the lower situations, therefore, is yellow pine. Sugar pine never grows in pure stands. Toward the lower limit of its range in the mountains it is found chiefly with yellow pine and incense cedar. This triple association is varied by the presence of Douglas spruce in the northern half of the State, especially in the cooler situations. Oaks, such as California black oak (*Quercus californica* (Torr.) Coop.) and tanbark oak (*Q. densiflora* Hook. and Arn.), also occur in mixture with sugar and yellow pine, usually forming an understory. When growing with yellow pine and

[a] There are many stands scattered through the Sierras that will closely approach this, notably in Plumas, Butte, Eldorado, Nevada, Sierra, and Placer counties. Some excellent stands also occur in the San Bernardino Mountains.

cedar the sugar pine is usually scattered singly through the stand, though the trees, as a rule, tower slightly above their associates.

At high elevations sugar pine is still found with yellow pine and cedar, but white fir has become its chief associate, and its proportion in the stand has increased. This is particularly true on northern and eastern slopes, where sugar pine and fir usually form the bulk of the stand. This association seems to be an excellent one silviculturally, since the sugar pine, which is an intolerant tree, slightly overtops the fir, while the tolerance of the fir enables it to endure the shading. Forests of this kind are often among the densest in the Sierras.

In addition to the trees already mentioned, sugar pine has sometimes other associates, such as red fir (*Abies magnifica* Murr.), Jeffrey pine (*Pinus jeffreyi*), and rarely lodgepole pine (*Pinus murrayana*). In scattered groves throughout the central part of the State, at elevations between 5,000 and 6,500 feet, on cool, well-drained flats, the big tree (*Sequoia washingtoniana* (Winsl.) Sudw.) occurs. Sugar pine is usually its chief associate, with cedar and fir next in importance, and often a few yellow pine.

Yellow pine has a considerable range where sugar pine does not occur. Toward the lower limits of its occurrence and on dry flats, such as the Shasta Plateau, it often grows in nearly pure stands. Usually, however, at such elevations, cedar is present in the stand, and on the Shasta Plateau both cedar and Douglas spruce are to be found associating as scattered individuals with the yellow pine.

At the lowest limit of its occurrence yellow pine is found with digger pine (*Pinus sabiniana*) and numerous oaks, chief among them California black oak and two white oaks (*Quercus lobata* and *Q. douglasii*). Other associates of the yellow pine are big-cone spruce (*Pseudotsuga macrocarpa*), in the San Bernardino and San Jacinto mountains, knob-cone pine (*Pinus attenuata*), and Coulter pine (*Pinus coulteri*).

In general, it may be said that yellow pine associates more or less with all the trees of the Sierras, but that, despite this fact, it has no characteristic associate, such as, at the higher elevations, sugar pine has in fir.

FOREST TYPES.

In order to facilitate the description of the sugar and yellow pine forests they have been divided into forest belts or types based chiefly upon differences in elevation.

In the Sierras four such belts or types may be distinguished: The foothill type, the yellow pine-sugar pine type, the fir type, and the timber-line type.

The foothill type is the first real forest type encountered after leaving the interior valleys; it extends from the lower foothills up to an elevation of from 1,000 feet to 1,500 feet in northern California, and as

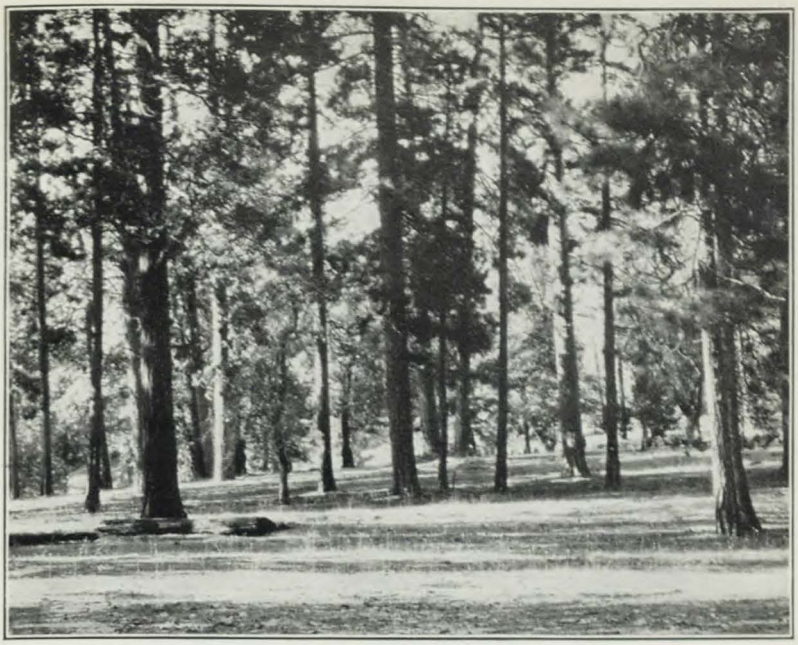

FIG. 1.—YELLOW PINE FOREST WITHIN THE LOWER PORTION OF THE YELLOW PINE-SUGAR PINE TYPE.

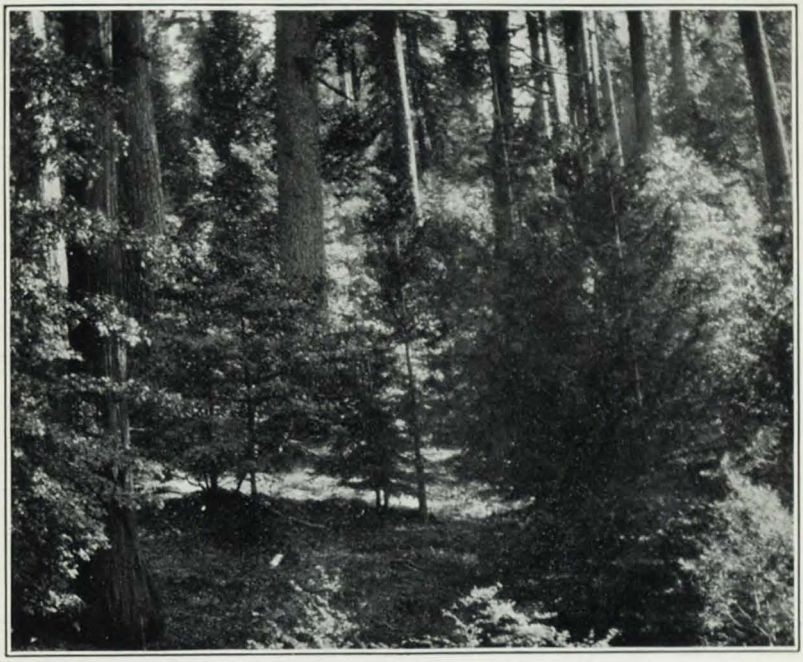

FIG. 2.—SUGAR PINE AND FIR FOREST WITHIN THE LOWER PORTION OF THE FIR TYPE.

Here is shown the great number of age classes found in the Sierra forests.

high as 3,000 feet in central California. In southern California this type is usually lacking, since the change from chaparral to the yellow pine is very abrupt. The type is characterized by a very open stand, consisting mainly of various species of oak, together with digger pine, and, toward the upper limit, some yellow pine of inferior quality. Underbrush is abundant, and is made up chiefly of various species of manzanita, California buckeye (*Æsculus californica*), laurel, and scrub oaks. The type is of very little commercial importance and need not be considered further. Table I shows the character of this type toward its upper limits.

Next above the foothill type is the yellow pine-sugar pine type. This type comprises the bulk of the commercial forest; in elevation it extends from about 1,500 feet up to 5,000 feet in northern California, and from about 4,000 feet to 8,000 feet in southern California. As the name implies, yellow pine and sugar pine are the important trees of this type. Toward its lower extension sugar pine is either very scarce or lacking, while yellow pine forms the bulk of the stand and is associated with incense cedar. The forest of this part of the type is more open, as a rule, than that higher up. The characteristic stand consists of a fairly even mixture of the five chief coniferous species, about 30 to 50 per cent of the stand being yellow pine, 10 to 20 per cent sugar pine, 20 to 30 per cent cedar, 15 per cent Douglas spruce, and 5 to 10 per cent white fir. A few scattered oaks are usually present. The stand, at its best, is rather dense, but in most localities fire and other causes have made frequent openings in it. On northern and eastern slopes Douglas spruce, white fir, and sugar pine form a larger percentage of the stand. In the gulches and about the heads of canyons Douglas spruce and white fir often constitute the bulk of the stand or are mixed with sugar pine, while along streams the California yew (*Taxus brevifolia*), alder (*Alnus rhombifolia*), dogwood (*Cornus nuttallii*), and the western serviceberry (*Amelanchier alnifolia*) are found. Toward the upper limit of the type the proportion of fir largely increases, while that of yellow pine decreases.

Underbrush is seldom thick, except in openings. Where it exists it is made up of various species of manzanita and ceanothus, together with coffeeberry (*Rhamnus crocea*) and several other species.

Table II shows the composition of this type at various elevations. Table III shows the composition near the border between it and the fir belt, as is shown by the increasing amount of fir and sugar pine.

The fir type, which is next above the sugar and yellow pine type, extends from about 5,000 feet elevation to 6,500 or 7,000 feet in northern California, while in southern California it lies mostly between 7,000 and 10,000 feet. On northern slopes, in the northern part of the State, it runs sometimes as low as 4,000 feet. The lower portion

of this type is generally a fairly even mixture of sugar pine and white fir, with a few scattered yellow pines and cedars. The fir and sugar pine are at first about equally represented, though occasionally sugar pine may predominate. The sugar pine in this portion of the type attains its best development, but with increasing elevation it becomes more and more short boled, flat crowned, and limby, and the number in the stand diminishes until it finally disappears altogether, and the forest becomes one of pure white fir or white and red fir mixed. Where fire has not killed the standing timber, this type is the densest of the four, and therefore very free from underbrush. In the openings occur some of the largest chaparral areas in northern California.

Within the region of this type numerous exceptions occur. For example, on southern slopes or on warm flats, with a good depth of soil, Jeffrey pine is often the prevailing species, associated with a few firs, cedars, and sugar pines. Again, where the underlying rock is close to the surface, and the soil consequently very shallow, the fir is replaced by lodgepole pine, often forming pure stands over considerable areas in the upper portion of the type.

In the timber-line type fir still forms a considerable portion of the stand, but the tree growth is stunted or scrubby, while such characteristic timber-line trees as white-bark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) are present. The type, however, is an unimportant one, and need not be further discussed.

It will be seen from the preceding paragraphs that elevation is the chief factor upon which the character of the stand depends. Next to this, slope and aspect have the greatest effect on its composition. Besides these, however, the character of the forest shows a certain amount of change from north to south. Perhaps the most marked is the decrease and final disappearance from the stand of Douglas spruce and the gradual increase in the amount of incense cedar.

The forests of the Sierras are approximately even aged, although, in common with all virgin stands, they include a wide range of diameter classes. Probably not more than 1,000,000 acres have been entirely cut over, and another million more or less culled. Good virgin timber will usually average about 25,000 feet to the acre, while individual acres sometimes yield as much as 100,000 feet, board measure.

STAND TABLES.

The stand tables which follow show by species the average stand of trees from 1 inch in diameter up. Each table is based on about 20 strip acres. Tables I and II give the total stand, and the stand above 1-inch, 12-inch, 18-inch, and 24-inch diameter limits, for each species, at various elevations. Tables III and IV differ from the others in that they show the distribution of the diameter classes.

It will be seen from Table II, which is for Butte County, that at 2,500 feet sugar pine and white fir figure very little in the stand, but that they occur in increasing quantity as the elevation increases. Douglas spruce, on the other hand, falls off rapidly and disappears almost entirely at 4,500 feet.

Table I is for similar elevations in Madera County, some 300 miles south of Butte County. It will be seen that the table for 2,500 feet in one county is very similar to the table for 4,000 feet in the other. In both Douglas spruce is lacking, since the locality is south of the range of this species in the Sierras.

Tables III and IV are for similar elevations, the one for Madera County, the other for Butte. Table III represents the yellow pine-sugar pine type, and Table IV the fir type. In both there is a wide range of diameter classes, which is explained in part by the presence of a younger growth, and in part by the variety of species and the varying conditions under which individuals have grown.

TABLE I.—*Average number of trees and percentage of each species per acre at various elevations in the foothill type, Madera County, Cal.*

AVERAGE OF 20 ACRES AT 3,000 FEET ELEVATION.

Diameter breasthigh.	Digger pine.	Western yellow pine.	Sugar pine.	Incense cedar.	California black oak.	Other species.	Total.
1" and over	28.95	12.60	.....	0.05	13.15	1.25	56.00
Per cent	51.70	22.50	.....	.09	23.48	2.23	100.00
12" and over	9.65	4.60	.....	.....	6.35	.40	21.00
Per cent	45.95	21.90	.....	.....	30.24	1.91	100.00
18" and over	2.30	2.30	.....	.....	3.25	.30	8.15
Per cent	28.22	28.22	.....	.....	39.88	3.68	100.00
24" and over	.95	1.20	.....	.....	1.85	.20	4.20
Per cent	22.62	28.57	.....	.....	44.05	4.76	100.00

AVERAGE OF 20 ACRES AT 4,000 FEET ELEVATION.

1" and over	.....	80.60	3.55	47.40	6.80	.....	138.35
Per cent	.....	58.26	2.57	34.26	4.91	.....	100.00
12" and over	.....	38.20	2.15	19.05	5.45	.....	64.85
Per cent	.....	58.90	3.32	29.38	8.40	.....	100.00
18" and over	.....	26.45	1.40	14.05	3.35	.....	45.25
Per cent	.....	58.45	3.10	31.05	7.40	.....	100.00
24" and over	.....	14.50	1.30	9.80	1.60	.....	27.20
Per cent	.....	53.31	4.78	36.03	5.88	.....	100.00

TABLE II.—*Average number of trees and percentage of each species per acre at various elevations in the yellow pine-sugar pine type, Butte County, Cal.*

AVERAGE OF 20 ACRES AT 2,500 FEET ELEVATION.

Diameter breasthigh.	Western yellow pine.	Sugar pine.	White fir.	Douglas spruce.	Incense cedar.	Other species.	Total.
1″ and over	50.65	6.15	0.45	32.35	10.45	18.90	118.95
Per cent	42.58	5.17	.38	27.20	8.79	15.88	100.00
12″ and over	15.05	2.20	.10	6.20	1.60	12.15	37.30
Per cent	40.35	5.90	.27	16.62	4.29	32.57	100.00
18″ and over	10.65	1.70	.10	5.50	.90	6.40	25.25
Per cent	42.18	6.73	.40	21.78	3.56	25.35	100.00
24″ and over	6.90	1.55	.05	4.60	.65	2.65	16.40
Per cent	42.07	9.45	.31	28.05	3.95	16.16	100.00

AVERAGE OF 20 ACRES AT 3,500 FEET ELEVATION.

1″ and over	34.40	11.80	23.30	13.50	13.70	3.90	100.00
Per cent	34.19	11.73	23.16	13.42	13.62	3.88	100.00
12″ and over	15.00	5.40	5.55	8.85	8.60	1.45	48.85
Per cent	33.45	12.04	12.37	19.73	19.18	3.23	100.00
18″ and over	11.95	4.40	4.35	7.80	6.25	.45	35.20
Per cent	33.95	12.50	12.36	22.16	17.75	1.28	100.00
24″ and over	9.10	2.75	2.95	6.30	4.20	.10	26.40
Per cent	34.47	14.21	11.27	23.86	15.91	.38	100.00

AVERAGE OF 20 ACRES AT 4,000 FEET ELEVATION.

1″ and over	59.17	23.57	23.81	6.10	20.16	16.78	149.59
Per cent	39.55	15.76	15.92	4.08	13.48	11.21	100.00
12″ and over	14.87	6.61	7.27	2.31	4.84	8.28	44.18
Per cent	33.66	14.96	16.46	5.23	10.95	18.74	100.00
18″ and over	11.60	5.59	6.26	2.08	3.43	4.26	33.22
Per cent	34.92	16.83	18.84	6.26	10.33	12.82	100.00
24″ and over	8.91	4.68	5.25	1.98	2.61	1.85	25.28
Per cent	35.25	18.51	20.77	7.83	10.32	7.32	100.00

AVERAGE OF 20 ACRES AT 4,500 FEET ELEVATION.

1″ and over	25.30	15.40	26.55	1.30	14.25	4.90	87.70
Per cent	28.85	17.56	30.27	1.48	16.25	5.59	100.00
12″ and over	18.15	10.55	13.50	1.05	10.35	2.35	55.95
Per cent	32.44	18.85	24.13	1.88	18.50	4.20	100.00
18″ and over	15.20	9.65	11.40	1.00	8.40	1.05	46.70
Per cent	32.55	20.66	24.41	2.14	17.99	2.25	100.00
24″ and over	12.20	8.85	9.30	.90	5.40	.25	36.90
Per cent	33.06	23.98	25.20	2.44	14.64	.68	100.00

TABLE III.—*Average number of trees and percentage of each species per acre at 5,000 feet elevation within upper limits of yellow pine-sugar pine type, Madera County, Cal.*

(Average of 20 acres.)

Diameter breasthigh.	Western yellow pine.	Sugar pine.	White fir.	Incense cedar.	California black oak.	Total.
Inches.						
1 to 10	6.35	7.95	11.85	16.90	0.30	43.35
12	.90	1.00	1.05	2.10	.40	5.45
14	.90	.50	.50	1.70	.35	3.95
16	1.70	.15	.35	1.60	.30	4.10
18	.65	.40	.55	1.20	.25	3.05
20	.55	.70	.30	1.10	.20	2.85
22	.90	.25	.35	1.05	.10	2.65
24	.90	.45	.60	1.50	.10	3.55
26	.50	.35	.80	1.05	.05	2.75
28	.80	.45	.55	.75	.....	2.45
30	.75	.55	.60	1.40	.05	3.35
32	.45	.25	.80	1.35	.....	2.85
34	.45	.55	.90	1.00	.....	2.90
36	.70	.40	.80	1.20	.10	3.20
38	.30	.50	.90	.75	.....	2.35
40	.40	.45	.80	.75	.....	2.40
42	.70	.65	.50	.40	.....	2.25
44	.40	.30	.65	1.10	.....	2.45
46	.65	.35	.40	.55	.....	1.95
48	.45	.40	.55	.30	.....	1.70
49 to 60	1.10	2.35	.65	.70	.....	4.80
61 to 84	.15	.30	.....	.....	.....	.80
Total	20.65	19.25	24.60	38.45	2.30	105.25
Per cent	19.62	18.29	23.37	36.53	2.19	100.00
TREES 12 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	13.75	10.70	12.25	20.25	1.65	58.60
Per cent	23.46	18.26	20.90	34.56	2.82	100.00
TREES 18 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	10.35	9.40	10.65	15.35	0.70	46.45
Per cent	22.28	20.24	22.93	33.04	1.51	100.00
TREES 24 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	8.35	8.20	9.10	12.10	0.25	38.00
Per cent	21.97	21.58	23.95	31.84	.66	100.00

TABLE IV.—*Average number of trees and percentage of each species per acre at 5,000 feet elevation within fir type, Butte County, Cal.*

(Average of 20 acres.)

Diameter breasthigh.	White fir.	Sugar pine.	Western yellow pine.	Incense cedar.	Other species.	Total.
Inches.						
1 to 10	16.04	2.50	1.95	3.80	1.20	25.49
12	1.20	.70	.35	.20	.40	2.75
14	.70	.30	.15	.20	.25	1.60
16	1.00	.20	.40	.65	.05	2.30
18	1.50	.50	.25	.25	.20	2.70
20	1.55	.40	.45	.60	.10	3.10
22	1.05	.35	.50	.20	.....	2.10
24	1.10	.45	.80	.30	.05	2.70
26	1.45	.70	.50	.60	.05	3.30
28	.85	.75	.70	.35	.05	2.70
30	.50	.30	.60	.50	.....	1.90
32	.65	.35	.75	.45	.05	2.25
34	.60	1.20	.55	.45	.05	2.85
36	.75	.90	.50	.50	.....	2.65
38	.70	1.10	.60	.25	.....	2.65
40	.80	.90	.55	.20	.....	2.45
42	.50	.55	.40	.25	.....	1.70
44	.30	.80	.10	.05	.....	1.25
46	.45	1.20	.55	.10	.05	2.35
48	.15	.95	.35	.10	.....	1.55
49 to 72	.65	3.15	.45	.25	.....	4.50
73 to 95	.....	.50	.....	.....	.....	.50
Total	32.49	18.65	11.45	10.25	2.50	75.34
Per cent	43.13	24.75	15.20	13.61	3.81	100.00
TREES 12 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	16.10	15.90	9.40	6.40	1.15	48.95
Per cent	32.89	32.48	19.20	13.08	2.35	100.00
TREES 18 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	13.05	14.65	8.45	5.25	0.50	41.90
Per cent	31.15	34.96	20.17	12.53	1.14	100.00
TREES 24 INCHES AND OVER IN DIAMETER BREASTHIGH.						
Total	8.90	13.50	7.00	4.25	0.25	33.90
Per cent	26.25	39.82	20.65	12.54	.74	100.00

DESCRIPTION OF THE SPECIES.

SUGAR PINE.

Sugar pine belongs to the white pine group, and botanically closely resembles its eastern relative, the white pine (*Pinus strobus*). It is a five-needle pine, with needles 3 to 4 inches long, rigid, usually erect, and of bluish or dark green color. The cones of the species are of remarkable size, sometimes 18 to 20 inches in length and from 3 to 4 inches in breadth. They require two years to ripen. The seeds are usually liberated in September or October, the cones persisting until the next spring or even longer. The seeds are from one-half to five-eighths of an inch in length, with broad, obtuse wings.

Sugar pine prunes itself well, surpassing the eastern white pine in this respect. This is an important factor in the value of the tree for lumber, since it enables it to form a clean stem much earlier in life. At maturity the sugar pine has a long, clean, symmetrical, and rather slowly tapering bole, surmounted by a flat, spreading crown.

The height growth of sugar pine is rapid, and the mature trees usually tower slightly above the rest of the forest. The tree has an average height of from 150 to 175 feet and a diameter of from 4 to 5 feet, although it may attain a maximum height of 235 feet and a diameter of 12 feet. At no period of its life does sugar pine have a deep root system, though that which it has is strongly developed and wide spreading, so that in spite of the absence of a taproot the tree is very wind firm.

In its demands upon the soil sugar pine is never very fastidious. The principal soils of the region in which it occurs are a rather light, loamy, or sandy soil resulting from the decomposition of outcropping schistose rocks, and a loose, rather coarse, gravelly soil, which results from the breaking down of the granite backbone of the Sierra Range. On both of these soils the sugar pine grows equally well, provided they are well drained, of sufficient depth, and not too dry. A third soil, and one to which it does not take so readily, is found in the Shasta region. It is a loose, dry, glacial drift, underlain by a subsoil of decomposed lava. The scarcity of sugar pine on this soil is, however, undoubtedly due to the extreme dryness of the surface soil, for on exactly similar soils where moisture is more abundant the tree is very thrifty. Sugar pine is found most often and does best in situations with moist atmosphere, where transpiration is slow, hence its preference for cool north and east slopes and heads of gulches and canyons. As might be expected from this, the sugar pine is unable to stand drought, especially when young, a fact that is of great importance in the reproduction of the species.

The sugar pine is an intolerant tree, possibly the most so of any of the Sierra conifers. It can not attain full development without an abundance of light, and is invariably suppressed or killed under heavy shade. In early youth, however, it is to a certain extent shade demanding, and in full light is apt to be stunted or even killed. The moister the air, of course, the less apparent is this shade-demanding quality, and on cool northern slopes young trees will sometimes thrive without any protecting shade. As it grows older the tree demands more and more light, and is usually seen with its crown fully exposed.

A scale of tolerance for the coniferous species of the Sierras beginning with the most tolerant would be: Incense cedar, white fir, Douglas spruce, yellow pine, sugar pine.

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The two pines are very close together in tolerance, but on the whole the yellow pine seems to stand suppression rather better than does sugar pine, hence it is placed ahead of it on the list. Both rank as intolerant species, while incense cedar and white fir are tolerant species, and Douglas spruce can hardly be called either tolerant or intolerant.

The sugar pine does not produce seed as early in life as do the other Sierra conifers. It is seldom that a tree less than 16 inches in diameter bears cones, and usually only trees 20 inches or more in diameter bear to any considerable extent. This species, moreover, is neither a regular nor a prolific seeder at any period of its life. Individual mature trees, it is true, often bear seed steadily, but in small quantities compared with either incense cedar or yellow pine. There are undoubtedly, at intervals, extra heavy seed years for sugar pine, but that there is any general regularity in their recurrence is extremely doubtful. Locally good seed crops occur at intervals of five to seven years, but sugar pine will be found seeding a little every year.

The principal Sierra conifers rank as seed bearers about as follows: Incense cedar, yellow pine, Douglas spruce, white fir, sugar pine.

In distributing its seeds the sugar pine, thanks to its height, can cover a considerable area, though this is somewhat offset by the size and weight of the seeds, which prevent very wide distribution by the wind. Ordinarily a tree will seed up the ground thoroughly at a distance from its base equal to its height. Wind, slope, and water can often be depended on to greatly increase this distance.

The sugar pine is not only the least prolific seed bearer, but it is one of the most particular species as to seed bed. It prefers a moist, rather loose, bed on which to germinate, such as the natural duff or humus of the forest floor affords, and will seldom germinate on bare mineral soil. The condition of the ground after fire is hardly favorable to sugar pine germination. Under even the best conditions sugar pine seed has not a high per cent of germination. Tests made by the Forest Service place it at about 25 per cent. In addition to this fact a large number of seeds are destroyed by squirrels and ground mice, the squirrels often stripping a tree of its cones before they are ripe and leaving a large part of the seeds to rot in the cones on the ground. These facts explain to a large extent the scarcity of sugar pine reproduction. Add to this the dependence of the young seedlings on the right degree of shade and it is at once apparent that to secure natural reproduction of the species is by no means easy.

Sugar pine seedlings are often found under the virgin stands, but they are never very abundant. The conditions of seed bed here are usually favorable to germination, but the shade is too heavy and in a short

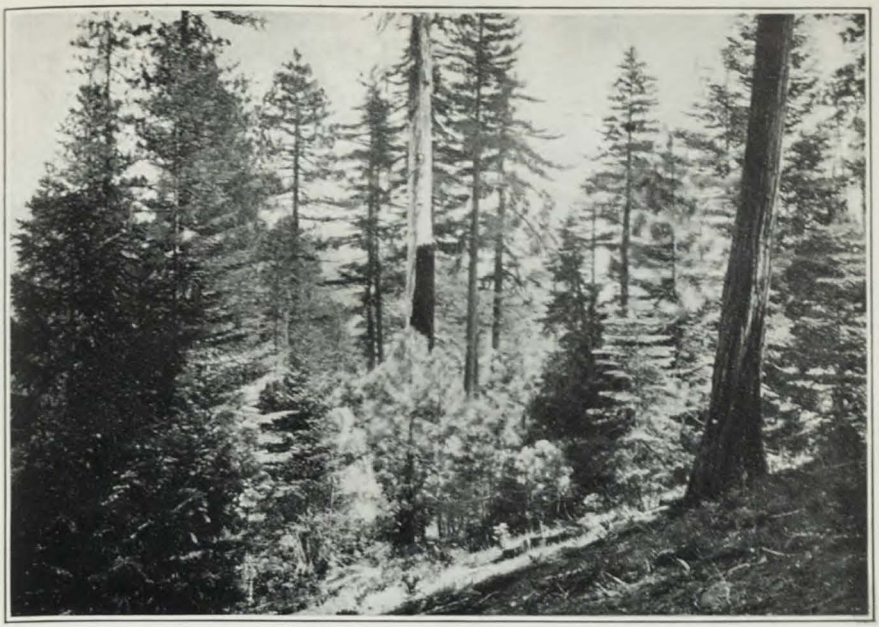

FIG. 1.—REPRODUCTION IN OPENING MADE BY FIRE AND INSECTS.
Here sugar pine is coming in together with yellow pine.

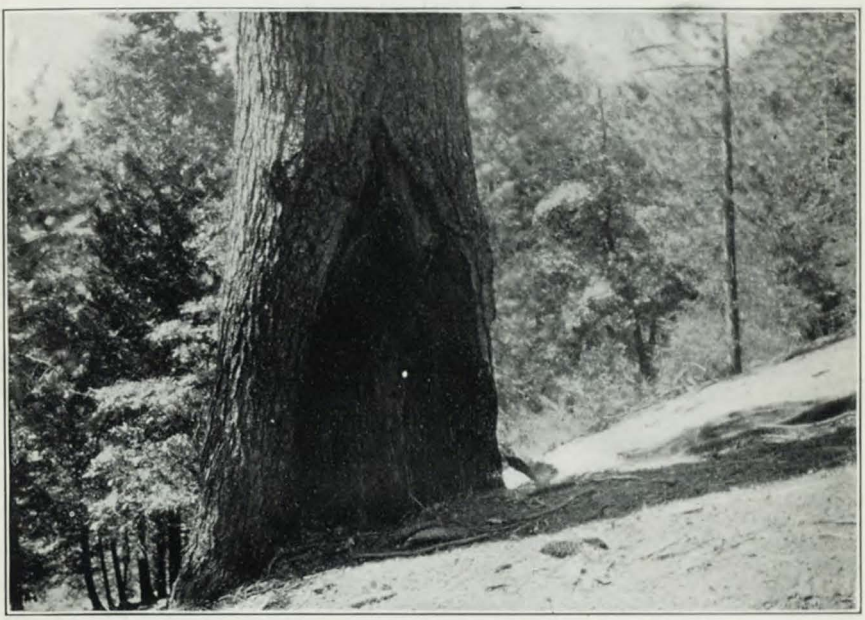

FIG. 2.—FIRE-SCARRED BASE OF A SUGAR PINE.
This necessitates cutting the stump very high, or else long butting of the first log.

time the young trees suffer from suppression, and soon die. In small openings in the virgin stand and along the edges of roads or broad trails cut through the virgin forest the conditions for sugar pine seem most favorable. Such openings are usually very quickly filled with young growth of all species, but the protection afforded by the side shade and the stimulation to rapid height growth from the overhead light are just the conditions that favor sugar pine, and its rapidity of height growth enables it to outstrip all competitors and ultimately to gain possession of the ground. It is probably by such means that sugar pine is enabled to hold its position in the virgin forest.

When lumbering takes place these conditions are entirely changed. The forest is cut clear, and any sugar pine that secures a start is likely to suffer from drought and exposure, while yellow pine, which is more adapted to such conditions, gains possession of the ground.

In some localities where lumbering was first carried on, only the larger trees were taken, and thus only a partial clearance made. In such localities sugar pine had a better chance, and it is here that the best reproduction and second growth are found. The species never reproduces in pure stands and seldom forms as much as 25 per cent of the young growth, but it seems fair to predict that some of these stands when mature will contain as much as 30 per cent of sugar pine. Excellent examples of the above conditions are to be found in Butte, Tehama, and Eldorado counties.

The power of mature sugar pine to resist fire is sometimes underrated, for in this respect it far surpasses eastern white pine and compares favorably with most of its associates. In youth all suffer about equally from fire, and are either killed outright or injured sufficiently to fall a prey to fungus and insect attacks. Up to the time it is an inch in diameter, sugar pine is killed outright, and from that time until the pole stage is reached it is usually killed ultimately by anything but the lightest ground fires. Mature trees are very rarely killed by fire, unless it should get into the crown, and although sugar pine has a much thinner bark than either yellow pine or Douglas spruce, it ranks well up in the list for fire resistance, the trees usually continuing to flourish without apparent permanent injury long after the butt has been badly burned.

In point of fire resistance the Sierra conifers rank as follows: Yellow pine, Douglas spruce, sugar pine, incense cedar, white fir.

Windshake in the mature trees is not uncommon, but is usually confined to localities where the nature of the topography renders winds unusually severe or where for one reason or another the tree does not grow at its best.

Sugar pine is not particularly susceptible to fungus attacks, since trees that are badly fire scarred often live for a long period without

suffering from fungus diseases. This is in part due to the six months' dry season, which is naturally inimical to fungus growth. In some localities, however, the mature trees suffer considerably from the attacks of "*Trametes pini*," which produces what is known as "red heart." It is claimed by some lumbermen that sugar pine growing on the Chico and Red Bluff ridges in Butte and Tehama counties is particularly bad in this respect, often 50 or 60 per cent of the mature sugar pine being infected more or less with red heart. It is significant in this case that rainfall in this region is as heavy as anywhere in the range of sugar pine in California. There are other fungus diseases to which the species is liable at different periods of its life, but the amount of injury from such causes is, on the whole, slight.

All the Sierra conifers are attacked by a parasite, a species of mistletoe (*Arceuthobium occidentale*), which grows on the limbs and small branches, drawing its food from the living cells of the tree. Sugar pine is probably freer from this parasite than any other species, and when mature trees are attacked the harm done is, as a rule, not great. Trees attacked early in life, however, are sometimes badly deformed, and young trees up to an inch or two in diameter are occasionally killed outright.

From insect injury sugar pine is again more immune than some of its associates. Attacks from insects that are capable of injuring healthy trees seem at present to be very local, and show little indication of spreading. Dr. A. D. Hopkins, in his report on his trip through the West (Bulletin 21, Division of Entomology, Department of Agriculture), makes the following statement:

> A Dendroctonus allied to the one just mentioned [*D. brevicomis*], but evidently undescribed, was found to be a special and dangerous enemy of the sugar pine and mountain white pine [*Pinus monticola*], especially of the latter. It was frequently met with in the vicinity of Grants Pass, Oreg., in sugar pine, and was found abundant in the bark of dying and dead standing and felled trees in the vicinity of Sand Point and Kootenai, Idaho, where a large amount of timber had died, evidently as a result of its attack. * * *
>
> It is undoubtedly capable of attacking and killing great quantities of white and sugar pine, but may possibly be prevented from doing so in the future, in all regions where extensive timber cutting is carried on, by its being attracted to the stumps, logs, and tops of trees felled for lumber and fuel. * * *
>
> Another species at present recognized as *Dendroctonus terebrans* was commonly met with in the bark of living, dying, and dead standing trees and the stumps of recently felled *Pinus ponderosa*, *P. lambertiana*, *P. monticola*, *P. murrayana*, *P. contorta*, and *P. radiata*, in all of the localities where these species of pine grow.

The sugar pine has, of course, many other insect enemies, some of which attack leaves, roots, twigs, or seeds, but that described in Doctor Hopkins's report is probably the worst.

Besides the enemies of sugar pine already discussed, there are numerous others that do it more or less harm. Squirrels and ground mice destroy the seeds, and cattle and sheep sometimes destroy the

young seedlings. In the case of cattle the injury is very slight, as they eat only the smallest seedlings of not more than a year or two in age; that they do eat these is, however, an observed fact. Sheep grazing is much worse, as the bands of sheep eat or destroy all the young reproduction in their path and leave the ground hard and trampled and in poor condition for seed germination.

YELLOW PINE.

The western yellow pine (*Pinus ponderosa*) belongs to the group of pitch pines known as the *ponderosæ*, of which *P. contorta* and *P. arizonica* are examples. It is a three-needle pine, though sometimes there are but two needles in a sheath. The needles are 3 to 6 or 8 inches in length and grow in thick clusters at the ends of the small branches. They usually persist until the third season. The cones form the first summer and mature the second, the seed being shed during the second fall, while the cones persist until the following winter or spring. They are from 3 to 6 inches long and are often borne in clusters.

The yellow pine has several varieties and closely allied species; of the latter by far the most important in California is the Jeffrey pine (*Pinus jeffreyi*). This so closely resembles the yellow pine that it is sometimes considered simply a variety. It grows almost entirely at high elevations, usually entering the forest where the yellow pine stops.

Yellow pine assumes a wide variety of forms, which depend largely upon the character of the situation in which it occurs. Under the best conditions it is a tall, rather full-boled tree, and has a height, when mature, of from 175 to 200 feet, and a maximum diameter of from 6 to 7 feet. A very noticeable feature in the development of the tree is its persistent height growth; that is, it never runs to limbs even when grown in the open. The limbs persist well toward the ground in such cases, but usually remain small. The mature trees have a very heavy, yellowish bark, with rather smooth, large, irregular plates. The bark is often from 2 to 3 inches thick.

The root system of the yellow pine is somewhat deeper than that of the sugar pine, although the mature trees have very little, if any, taproot. The young seedlings, however, develop a long taproot, especially in dry situations. In such places the growth below ground during the first year will sometimes be two or three times that above ground. Later, however, the tree develops a strong lateral root system which renders it very wind firm.

Yellow pine is not fastidious in its demands upon soil moisture. Its remarkable ability to stand drought and to occupy unfavorable locations are factors which largely explain its wide range. It does

best, however, on a rather loose, sandy loam or gravelly loam soil that is well watered and well drained. In the Sierras such conditions are found on the beds of the old filled-in lakes. Often yellow pine will be found growing well on very dry soil, such as the glacial drift of the Shasta Plateau, but it is probable that the subsoil is well watered there and that the depth of the tree's root system renders accessible a good supply of moisture.

The yellow pine is decidedly a light-loving tree; even a slight degree of shade perceptibly retards its growth. But the hardy nature of the species seems to permit it to survive for a longer period under shade than some trees no less tolerant. If not shaded too long it will recover, but shade-grown trees are always more spindling in form and show a decided suppression in height growth. The ability of yellow pine to withstand drought makes it capable of enjoying full sunlight from the start. In the scale of tolerance it ranks next to sugar pine at the end of the list.

Next to incense cedar yellow pine is the most prolific seed bearer of the Sierra conifers. Moreover, there seems to be a large degree of regularity in the occurrence of seed years. Heavy seed years occur about once every three or four years. Unlike the sugar pine, however, yellow pine bears very little seed during the intermediate years.

The seed of the yellow pine is well scattered, and a single tree is often able to seed up a considerable area. The trees begin bearing seed at a much earlier age than sugar pines, but trees under 12 or 14 inches in diameter seldom bear very heavily.

The seed is shed in the fall and usually germinates the same season. Yellow pine is not very particular about seed bed and may be found germinating on the bare mineral soils, but the germination is much better where the seed bed contains more moisture. Often on lumbered areas within the virgin forest it will be found that young seedlings are much more abundant on the patches of squaw carpet (*Ceanothus prostratus*) than elsewhere. This is undoubtedly due to the moisture-retaining qualities of this form of ground cover. Yellow pine seed has a fairly high percentage of germination. Tests made by the Forest Service place it at about 70 per cent.

As might be expected from the seeding capacity and hardy character of the species, reproduction and second growth are abundant wherever light is plentiful and seed trees present, provided, of course, fire is absent. Yellow pine may be found reproducing even under the heavy virgin stands, but lack of light prevents its surviving beyond the first few years. Under partial shade the yellow pine will hang on in a suppressed condition much longer, but it is in the large openings made by lumbering or fire that reproduction is at its best. The full light to which the species is partial and its ability to withstand

drought, combined with its rapid height growth, render it particularly adapted to occupy such areas, oftentimes to the exclusion of almost all other species. It is this fact that either has entirely changed or is changing the character of the stand on areas where lumbering is carried on, so that the relative amount of yellow pine in the future Sierra forests bids fair to greatly exceed that in the present virgin stand.

In its power to resist fire, yellow pine surpasses all its associates. The young trees, as in the case of other species, are easily killed or permanently injured by fire, but with the larger and mature trees the thickness of the bark is an excellent protection against ground fires, and even after the bark has been burned through on one side the tree usually continues to thrive. Mature trees are sometimes killed by fire, or sufficiently injured by it to fall victims to insect attacks, but this is the case only when the fire is excessively hot and the crown is more or less affected.

While not so free from injury by natural enemies as the sugar pine, yellow pine does not, as a rule, suffer greatly in this way. Wind does very little damage to the species. Wind-shake is not common, and, outside of a few very exposed ridges, the total effect of wind on the tree is so slight as to scarcely deserve mention. Yellow pine often suffers, however, from fungus diseases. Among the mature trees conk, or red heart, is fairly common, and very old trees which have been injured by fire will almost invariably be found to be more or less affected by red heart, which is due to a fungus (*Trametes pini*). Generally, however, the yellow pine, except overmature trees and those that have suffered from some other form of injury, seems to be exceptionally free from fungus diseases within its California range.

Like the other Sierra conifers, the yellow pine is a host plant for the parasite *Arceuthobium occidentale*. It is more subject to it than sugar pine, though less so than cedar or fir. Most of the damage done is to the limbs, which become crooked and gnarled and eventually die.

Yellow pine suffers from insect attacks probably more than any other western conifer. Doctor Hopkins says of it in his report on his western trip:

> It has in *Dendroctonus brevicomis* a most pernicious enemy, which penetrates and excavates winding galleries through the living bark of the finest trees, speedily causing their death. Very many trees have died and are dying from this cause, and the dead ones are contributing to the spread of forest fires. Its next greatest enemy is the pine butterfly, which has from time to time defoliated and caused the death of much of the best yellow-pine timber in eastern Washington and in Idaho.
>
> There are many secondary enemies of greater or lesser importance among the Scolytid genera *Pityophthorus*, *Pityogenes*, *Xyloterus*, *Tomicus*, *Hylastes*, and *Hylurgops*, which contribute to the death of trees primarily injured by defoliating and other insects, fire, and other causes. Numerous Buprestid and Cerambycid enemies of the wood and bark contrib-

ute to the unhealthy condition of the timber and the destruction of the wood. Coleopterous larvæ infest the terminal twigs of young trees near Moscow, Idaho, and one or more Curculionid beetles breed in the bark at the base of young and old trees.

The Dendroctonus mentioned by Doctor Hopkins has already done considerable damage in the neighborhood of McCloud, Cal., and has commenced its depredations in the Yosemite region. *Tomicus confusus*, the species which kills fire-injured young sugar pines, is also found in young thickets of yellow pine wherever fire has injured them.

It seems probable that in the near future the frequency of insect attacks on the yellow pine will become a very serious factor in dealing with the forests, since their relation to lumbering and fire is such that in many places the conditions are ripe for their increase. Yellow pine when growing pure seems in greater danger of widespread destruction than when mixed with other species, and the increasing number of pure yellow pine stands is an additional menace of danger from this source.

Aside from the three sources of injury already mentioned, yellow pine has few enemies, nor does it suffer much from grazing or the like. An injury, the cause of which has ceased but the effect of which is still visible in Butte and Tehama counties, is that caused by boxing. During the civil war most of the yellow pine in the region was boxed for turpentine, the high price of which made this a profitable undertaking. After the war, when the price for turpentine was again normal, it ceased to be profitable to exploit the western yellow pine for this purpose. The quality of the timber cut from these boxed trees, however, has been greatly lowered, owing to this early boxing.

GROWTH.

The following tables show the growth of sugar pine and yellow pine in height, diameter, and volume.

Tables V and VI show the diameter breasthigh and the total height for sugar and yellow pine at different ages. The growth for yellow pine is shown in two localities, the first in northern California and the second in central California.

It will be seen that sugar pine is rather slow in both height and diameter growth up to the fortieth year, when both increase rapidly and continue for the next hundred years. This is due to the fact that most of the sugar pines have been shaded more or less in their early youth. For this reason it is believed that, under a suitable system of management, the sugar pine will have a much more rapid growth than that shown in the tables. This belief is borne out by the fact that trees grown under more favorable conditions show far better growth than the average which is shown in the tables.

Yellow pine, it will be seen, has a much more rapid height and diameter growth than sugar pine, but this growth begins to fall off more rapidly, and at the age of one hundred years or more it is surpassed by the sugar pine, which maintains its growth much longer and attains a greater maximum height and diameter.

TABLE V.—*Rate of growth in diameter and height of sugar pine.*

Age.	Diameter breast-high.	Height.	Age.	Diameter breast-high.	Height.
Years.	*Inches.*	*Feet.*	*Years.*	*Inches.*	*Feet.*
10.....	0.7	7	110.....	20.9	103
20.....	2.5	15	120.....	23.0	113
30.....	4.1	22	130.....	24.9	122
40.....	5.8	29	140.....	26.6	128
50.....	7.8	39	150.....	28.2	134
60.....	9.9	49	160.....	29.3	138
70.....	12.2	60	170.....	30.4	140
80.....	14.4	70	180.....	31.4	143
90.....	16.5	81	190.....	32.0	144
100.....	18.7	92	200.....	32.4	144

TABLE VI.—*Rate of growth in diameter and height of yellow pine.*

Age.	Butte County.		Madera County.	
	Diameter breast-high.	Height.	Diameter breast-high.	Height.
Years.	*Inches.*	*Feet.*	*Inches.*	*Feet.*
10.....	0.4	6	0.5	6
20.....	2.3	12	4.0	20
30.....	4.3	19	7.2	38
40.....	6.5	29	10.0	51
50.....	8.9	44	12.4	61
60.....	11.4	57	14.3	68
70.....	13.8	69	16.0	75
80.....	16.1	79	17.4	81
90.....	18.1	87	18.9	87
100.....	20.0	94	20.3	94
110.....	21.7	99	21.4	100
120.....	23.3	104	22.5	105
130.....	24.6	108	23.6	111
140.....	25.8	112	24.6	116
150.....	27.0	115	25.5	120
160.....	28.0	118	26.4	123
170.....	29.0	121	27.2	126
180.....	29.8	123	28.0	128
190.....	30.6	125	28.7	130
200.....	31.3	127	29.4	132

Tables VII and VIII show the average logged volume of sugar pine and western yellow pine for trees of different diameters, scaled by the Spalding Log Rule. It will be noted that yellow pine runs somewhat higher throughout. This is due to the fact that the cull from charred butts is greater in the case of sugar pine, whereas the yellow pine loses very little from this cause.

TABLE VII.—*Volume of sugar pine.*

Diameter breast-high.	Trees under 100 feet high.	Trees over 100 feet high.	Diameter breast-high.	Trees over 100 feet high.
Inches.	*Board feet.*	*Board feet.*	*Inches.*	*Board feet.*
12	20	.....	37	2,025
13	40	.....	38	2,175
14	60	.....	39	2,340
15	80	.....	40	2,500
16	110	140	41	2,665
17	140	175	42	2,850
18	180	220	43	3,040
19	225	265	44	3,225
20	270	310	45	3,400
21	325	365	46	3,600
22	375	425	47	3,800
23	435	485	48	4,000
24	500	550	49	4,215
25	565	630	50	4,440
26	640	715	51	4,675
27	715	800	52	4,900
28	790	900	53	5,150
29	875	1,000	54	5,400
30	950	1,110	55	5,675
31	1,040	1,225	56	5,975
32	1,125	1,350	57	6,275
33	.....	1,475	58	6,600
34	.....	1,610	59	6,900
35	.....	1,750	60	7,215
36	.....	1,875		

TABLE VIII.—*Volume of western yellow pine.*

Diameter. breast-high.	Trees under 100 feet high.		Trees over 100 feet high.	
	Butte County.	Madera County.	Butte County.	Madera County.
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*
12	.....	25	.....	.....
13	20	40	.....	.....
14	45	60	.....	.....
15	75	85	.....	.....
16	105	115	.....	.....
17	150	155	230	.....
18	200	195	285	.....
19	260	250	345	.....
20	325	315	405	450
21	400	380	470	520
22	470	450	540	595
23	540	530	615	685
24	615	610	700	780
25	690	695	790	885
26	770	770	900	995
27	850	850	1,020	1,120
28	930	925	1,150	1,255
29	1,010	.....	1,290	1,400
30	1,090	.....	1,460	1,545
31	1,170	.....	1,635	1,710
32	1,250	.....	1,810	1,895
33	.....	.....	1,990	.....
34	.....	.....	2,170	.....
35	.....	.....	2,350	.....
36	.....	.....	2,520	.....
37	.....	.....	2,710	.....
38	.....	.....	2,890	.....
39	.....	.....	3,070	.....
40	.....	.....	3,240	.....
41	.....	.....	3,425	.....
42	.....	.....	3,605	.....
43	.....	.....	3,800	.....
44	.....	.....	3,990	.....
45	.....	.....	4,170	.....
46	.....	.....	4,350	.....

Table IX shows the relation between height and diameter for both sugar pine and yellow pine. It will be seen that the two are remarkably close, though the sugar pine tends to be slightly taller in proportion to its diameter than the yellow pine.

TABLE IX.—*Comparative heights of sugar pine and western yellow pine.*

Diameter breast-high.	Sugar pine.	Yellow pine.		Diameter breast-high.	Sugar pine.	Yellow pine.	
	Butte County.	Madera County.	Butte County.		Butte County.	Madera County.	Butte County.
	Height.	Height.	Height.		Height.	Height.	Height.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*
1	8	8	7	21	103	98	97
2	13	11	10	22	108	103	100
3	17	16	14	23	113	108	103
4	21	20	17	24	118	113	106
5	26	25	22	25	122	118	109
6	30	31	27	26	126	122	113
7	35	37	33	27	130	125	115
8	40	42	39	28	134	128	118
9	44	47	45	29	137	131	121
10	49	51	50	30	140	134	124
11	54	55	55	31	142	136	126
12	59	59	61	32	144	138	129
13	64	63	65	33	145	140	131
14	68	67	70	34	146	142	134
15	73	71	74	35	147	143	136
16	78	75	79	36	148	145	139
17	83	79	83	37	150	146	141
18	88	83	86	38	151	147	144
19	93	88	90	39	152	148	146
20	96	93	94	40	152	149	148

WOOD.

SUGAR PINE.

The wood of sugar pine is soft, straight grained, and easily worked. It is very resinous, and the resin ducts are large and conspicuous. The heartwood is light brown in color, while the sapwood is yellowish white. When finished, the wood has a satiny luster that renders it excellent for interior finishings.

The specific gravity of the dry timber is 0.3684, and rough dry timber averages about 2.5 pounds to the board foot.

In contact with the soil sugar pine shows moderately durable qualities, although this might prove less apparent in a climate not so dry as that of California. In brief, sugar pine closely approaches the eastern white pine in its physical characteristics.

The following table, the figures for which were taken from the Tenth Census Report, will show the relation between the two woods:

	Coefficient of elasticity.	Ultimate transverse strength in kilos.	Ultimate resistance to long crushing.	Resistance to indentation.
Sugar pine	794	255	3,382	1,244
White pine	851	267	6,219	1,194

Specific gravity:
Sugar pine 0.3689
White pine ..... .3854

Although these figures are not based on a sufficient number of tests to make them conclusive, they are accurate enough to indicate that the two woods are very close, though the eastern white pine is a trifle the stronger. On the whole, it seems safe to say that sugar pine is slightly inferior to white pine in quality as well as in strength, for it is more brittle, and its large, conspicuous resin ducts are somewhat of a detraction.

Sugar pine timber has an almost endless variety of uses. It is used extensively for doors, blinds, sashes, and interior finish. In pattern work sugar pine is largely replacing white pine, as it is cheaper and its softness and straight grain render it an excellent substitute. Its freedom from odor or taste causes the wood to be much used in the manufacture of druggists' drawers.

Other common uses are for oars, moldings, ship work, chain boards, bakery work, cooperage, and woodenware—in short, for almost any purpose for which white pine is used. The poorest grades are used extensively for boxes, especially fruit boxes, and for drying-tray slats.

The wood is still used for making shakes (a hewed shingle 36 inches by 6 inches), and its straight grain and the ease with which it splits have made this in the past almost the first use for which the tree was sought. Logs too knotty to cut uppers, but otherwise sound and straight grained, are sometimes turned into bolts for match wood.

YELLOW PINE.

The wood of yellow pine varies as greatly as do the silvical characteristics of the tree. In one locality alone four kinds of trees are distinguished, the classification based largely on the character of the wood. The wood is rather heavy as compared with that of sugar pine, is hard and strong, sometimes brittle, and very resinous. The heartwood is reddish brown, and the sapwood yellowish white and often very thick. The sapwood from certain trees, when finished, has a beautiful satiny luster, is light and easily worked, and is equal to sugar pine for finishing purposes.

Yellow pine has a specific gravity when dry of 0.4715, and rough dry lumber weighs about 2.7 pounds per board foot. It is thus considerably heavier than sugar pine and is proportionately stronger.

Yellow pine has a great variety of uses, especially where a strong, durable wood is desired. It is extensively used for building materials, such as scantling, beams, flooring, ceiling, etc., railroad ties, door stock, and matches. Small trees 6 inches, 8 inches, and 10 inches in diameter are extensively used in some localities for mine props; in fact, the use of yellow pine for mining timber was one of its earliest uses.

COMMERCIAL IMPORTANCE.

An idea of the relative commercial importance of yellow and sugar pine may be gained from a few statistics of cut. According to the Twelfth Census, the total timber cut in California for the year 1900 was 864,665,000 board feet, made up as follows:

	Feet.
Yellow pine	289,095,000
Sugar pine	52,308,000
Redwood	486,191,000
Other species	37,071,000
Total	864,665,000

The total cut for the year 1904 was, in round numbers, 900,000,000 feet, as follows:

	Feet.
Yellow pine	289,000,000
Sugar pine	120,000,000
Redwood	400,000,000
Other species	90,000,000

The yellow pine cut has remained practically stationary, while that of sugar pine has more than doubled. The increase in the cut of sugar pine is natural, owing to the increased demand for the species, but as yellow pine is always cut in conjunction with sugar pine it is not so apparent why yellow pine should have remained stationary. This, however, is probably due to two causes: First, yellow pine has followed a slight slump in the market, and the mills cutting yellow pine chiefly have curtailed their output, especially as the season of 1904 was somewhat shortened by early and late rains; sugar pine, on the other hand, has remained steadier in price; in fact the demand for the upper grades has at times almost exceeded the supply; second, yellow and sugar pine are very closely united in the market, and the steadier prices for sugar pine have doubtless led to the marketing of better qualities of yellow pine (or white pine, as it is known in the market) under the name of sugar pine, thus swelling the figures for the sugar pine output and decreasing those for yellow pine.

Redwood, according to the tables, shows a falling off, due, doubtless, to the fact that there has been a slight slump in the redwood market during the past year and also to the fact that the production of redwood has nearly reached its height. The increase in the cut of other species is largely due to the increase in the use of white fir and incense cedar, and is a part of the general growth of the lumber industry within the State.

Yellow and sugar pine together form very nearly one-half the output of the State, and if the amount of other species cut by the sugar and yellow pine mills is considered, they form more than half the lumber industry of the State. This division of the industry, namely, redwood on one hand and sugar and yellow pine on the other, is a

geographical one and extends to the mills and market as well. From a market or commercial standpoint sugar pine and yellow pine may therefore be considered by themselves.

Of the total cut of yellow and sugar pine, about 55 per cent is cut by 8 mills, while the rest of the cut is distributed among 30 or 40 smaller mills. Of all the sugar pine cut in the State, over 70 per cent is cut by 5 companies, which cut sugar pine chiefly, and the rest of the cut is distributed among 15 or more companies.

The most important factor of the sugar and yellow pine market is the competition of Washington and Oregon lumber, which has practically driven these two woods out of the general California market and entirely out of the San Francisco market. This is due to the cheapness of Oregon and Washington lumber, and to the fact that the San Francisco market can be reached at a smaller cost for transporation by the Oregon and Washington lumbermen than it can by the California sugar and yellow pine producers. For example, the water freight rate per thousand feet from Portland to San Francisco is but $3.25, while the average rate per thousand for rail shipments from the San Joaquin and Sacramento valleys is $5. The extent of the competition may be realized when it is known that 700,000,000 feet were shipped into California last year, and although a large part was undoubtedly reshipped, a good proportion remained in the State. To meet this competition and to open up markets outside the State, the sugar pine and yellow pine producers have organized what is known as the California Sugar and White Pine Agency. This agency to some extent regulates the output and prices, but actually handles but 35 per cent of the total output, and this 35 per cent is wholly made up of the upper grades. These grades are for the most part marketed outside the State, the sugar pine going largely to the eastern seaboard, where it is sold for from $50 to $65 per thousand and competes with corresponding grades of eastern white pine. In fact, there is at present very little trouble in marketing the better grades of this timber. Some sugar pine also is distributed through the Middle West, where it goes to supply sash, door, and blind factories, and the like. Very little sugar pine goes abroad.

The yellow pine competes to some extent in the Los Angeles market, but it has rather lost ground to Oregon fir in the last few years. The principal market lies throughout the Middle West, where it competes successfully with southern pines. Last year about 5,000,000 feet of the upper grades were exported. Of this, 4,000,000 feet went to Australia and New Zealand, while the remainder went to Europe by way of Galveston, principally to Liverpool, Belfast, and Glasgow.

It is in the marketing of the lower grades, however, that the sugar and "white" pine producer meets the greatest difficulty. The freight rates—75 cents per hundred pounds to the Atlantic seaboard and 60

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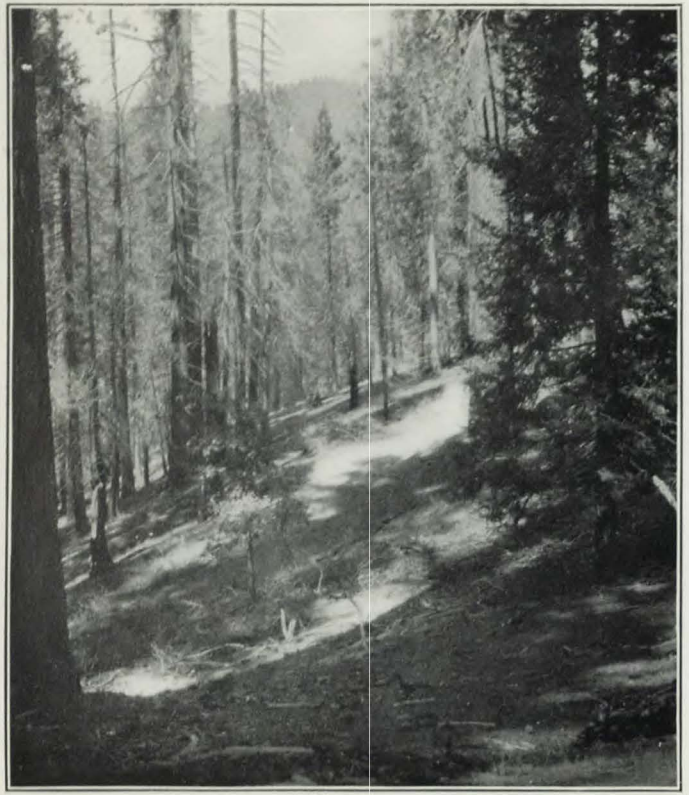

FIG. 1.—FIRE-KILLED TIMBER IN YELLOW PINE-SUGAR PINE BELT.

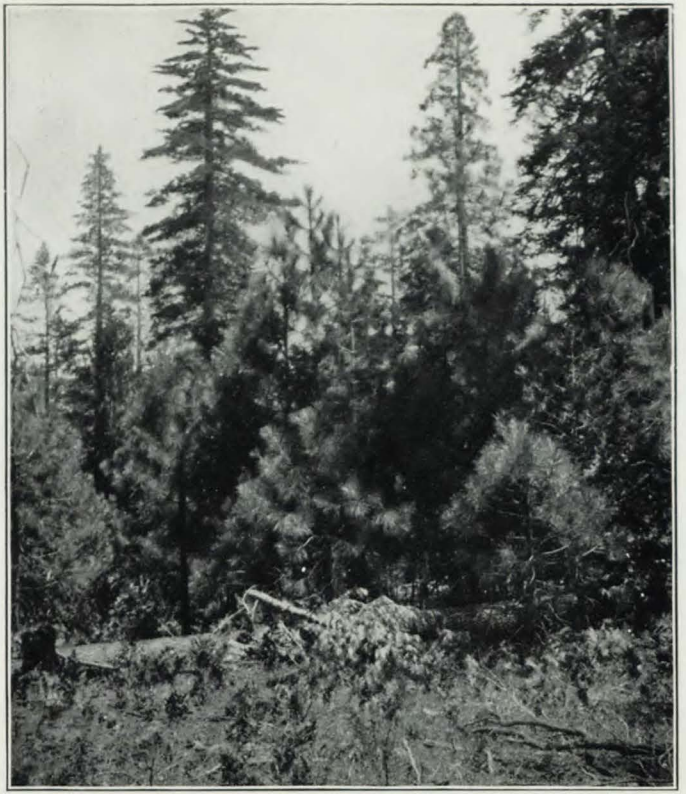

FIG. 2.—REPRODUCTION OF SUGAR PINE AND YELLOW PINE ON PARTIALLY LUMBERED LAND.

cents to Chicago—effectually closes the eastern market to these grades of lumber. Forced to look for his market nearer home, the producer has developed the box industry and his own local market. Considering that approximately 50 to 60 per cent of the sugar and yellow pine cut is in the lower grade—that is, commons—and that the bulk of this is manufactured into boxes, the magnitude of the industry may be appreciated. Most of the sugar and yellow pine companies now operate their own box factories or else supply a box factory in their immediate neighborhood. They thus supply the fruit growers of southern California with fruit boxes, but even here they meet with competition from the yellow pine lumbermen of New Mexico and Arizona, who, through lower railroad rates westward to stimulate the haul, can often put their boxes into southern California as cheaply as or more cheaply than the California lumbermen themselves. Thus, although the market for sugar and "white" pine is good, it is far from what it might be. Improved market conditions are largely dependent upon the state of the industry in Washington and Oregon, and such periods of overproduction in the Northwest as have occurred in the past two or three years have necessarily been felt by the sugar and yellow pine producers. As conditions improve, however, and the eastern and foreign markets reach their full development, prices will undoubtedly rise.

The agency grades pine as follows: No. 1, 2, and 3 clear; 1, 2, and 3 siding; 1 and 2 shop, and common or box lumber. All except the last named are classed as uppers. No. 2 shop, however, is sometimes classed as uppers and sometimes as common, and it is largely this grade which is used in the sash, door, and blind factories.

Uppers of sugar and "white" pine range from $30 and $40 up, f. o. b. the cars in California. Special grades, such as extra thick, etc., bring as high as $60 or $65 f. o. b. One large company lays down the best grade sugar pine, ordinary dimensions, at $55 per M in New York. No. 2 shop brings about $16 f. o. b. In spite of this, however, the mill run averages about $17 per thousand, f. o. b. at the point of shipment.

FIRE.

It is safe to state that the effect of fire on the virgin forest has been that of thinning it. The greater part of California's pine forests to-day are not producing within 25 per cent of the timber which the land is capable of producing.

Forest fires in California are usually ground fires, and as the mature trees of all species are more or less fire resisting, these fires seldom kill the timber outright, nor does a single fire greatly affect the virgin forest as a whole. It is their repeated occurrence and the cumulative effect that does the harm. Trees are gradually eaten away at the base and later are broken off by the wind or yield to fungus and insect

attacks, thus continuing to effect the thinning of the stand. This thinning would be offset by the new growth which ordinarily would replace the mature trees as they dropped out of the stand, but such replacement usually has been and still is prevented by the same fires which destroy outright all young growth.

In many portions of the State where fires have been exceptionally bad this process has gone so far that the tree growth has been entirely replaced by chaparral. Now, not only are these chaparral areas objectionable, in that land suitable for growing timber is occupied by worthless brush, but they are a great menace in themselves. Such areas are usually subject to fire, and the fires which rage across them are among the worst of the region. If these fires destroyed the chaparral, they might be of advantage; but, owing to the fact that most of the species which constitute it have the capacity of sprouting from the root, each succeeding fire but serves to enlarge the chaparral area. If fires were kept out of such areas, these would gradually revert to forest growth, as is conclusively proved by the number of seedlings to be found coming up in the chaparral along the borders of the forest.

The charring of the butts of mature trees has also another side, namely, the actual loss of merchantable timber in standing trees whose bases have been scarred. That such loss is by no means insignificant was demonstrated by scaling in the woods all the sugar pine cut by one lumber company for two weeks and deducting the loss in fire-scarred butts left in the woods and the decrease in the scale of logs taken to the mill.

As cut, these logs scaled 613,722 board feet. The charred butts left in the woods scaled 25,286 feet and the deduction for cull on the charred logs taken to the mill was 7,523 feet. Thus the total cull amounted to 32,809 board feet, or a loss of 5.3 per cent of the yield of the trees had they been uninjured by fire. When it is remembered that all of this is in the butt log, which usually gives the best grades of lumber, the damage will be still further emphasized.

The great danger from fire in California lies in the prolonged dry season, during which the forest floor becomes as dry as tinder and is easily ignited. As in all regions where lumbering is carried on, the lumbered areas are extremely liable to catch fire, and such fires are of the hottest, particularly in a region where the amount of débris left on the ground is so large and the dry season so pronounced.

LUMBERING.

Lumbering to supply the general demand is of rather recent origin in California. Cutting the timber for local use, particularly in the Sierras, practically began with the opening up of the country that followed the gold rush in 1849. Timber was soon in demand for mining and building purposes, and it was not long before small sawmills

started up, usually in the neighborhood of the mining camps. Yellow pine was used largely for mining timbers, while sugar pine was especially sought for shakes. At the outset these two species alone were cut. Within the last fifteen years, however, there has been a rapid growth in the industry. The opening up of the country by new railroads, the increasing demand for timber, and the exhaustion of the eastern timber regions have all combined to give lumbering a tremendous impetus. At present, mills capable of cutting 100,000 feet or more a day are to be found all over the State. This growth of lumbering on a large scale has been accompanied by the adoption of the most modern methods of logging and handling the timber. All the large companies now operate their own railroads, and the size of the logs compels the use of the best appliances for handling them in the woods.

In California lumbering operations of any size may be divided into two classes—lumbering with a railroad alone, and lumbering with a flume and a railroad. The railroad is almost everywhere used to get the logs from the woods to the mill, but in many cases it has been considered impracticable to connect the logging operations with the tracks of the nearest railroad company by a logging railroad, owing to the distance to be covered and the difficulty of getting the logging road from the valleys into the mountains. In such cases the mill is situated in the mountains near the logging operations, and the sawed lumber is transported by a flume, often 50 or 60 miles in length, to the company's yards and planing mills, situated, as a rule, on the main line or a branch of some railroad. Lumber above certain dimensions can not be transported by flume and has to be hauled, which is always an expensive operation.

Logging in the woods is almost everywhere done with steam engines and slides. In a few instances, however, where the level character of the country permits, the large wheels so common in the longleaf pine forests of the South are used. In the construction of slides fir and cedar are used whenever possible. The slides are usually of the three-log "fore-and-aft" order.

The usual method is to snake the logs from the stump to the head of the slide or one of its branches by means of a light yarding donkey. The logs are then made up into trains and hauled down the slide to the railroad by a large bull donkey engine located at the foot of the slide.

Snaking out the logs invariably plows up the ground and destroys young growth along the way, but since the logs from one tree and often from a group of trees take the same course the forest floor is not torn up as much as might be expected. Young growth of value generally comes up in an opening of the old stand, and as no logs are afterward taken from the vicinity, it usually escapes injury.

As in most lumber regions, an increasing number of species are being cut, while the minimum diameter limit is becoming steadily smaller. Formerly only sugar pine and western yellow pine were cut. Now almost all sound spruce is taken, together with a certain amount of the best fir and cedar, and in some localities practically all merchantable-sized, sound trees of all five species go to the mill. This of course makes the cutting much cleaner than formerly.

At present very few companies cut trees of a diameter under 24 inches on the stump. In the last few years a few lumber companies have been cutting trees down to 18 inches, or even smaller. The contract for cutting for one company in particular calls for the felling of trees down to 13 inches in diameter on the stump, but very few stumps are found that measure less than 17 or 18 inches in diameter. Cutting to 24 inches, however, means practically clear cutting, since the stands are approximately even aged. Trees that fall below this limit are mostly those that have suffered by suppression or have come up in some opening made in the older stand. Often both these classes are sufficiently healthy to make good seed trees and the number of them to the acre is sufficient to furnish a fair seed supply, but, unfortunately, at present no effort is made to protect them, and many are injured during the logging operations, while others are later killed by fire.

The young growth which sometimes exists on the ground being logged is of course disregarded, and it is very much to be doubted whether anything can be done to save it, and, further, whether it is worth while.

From a financial standpoint there is almost no waste in logging, though often the actual waste of timber is considerable. Stumps are cut 3 feet in height or even less, merchantable logs are seldom left in the woods, and the trees are cut fairly well into the tops. The size at the end of the last log varies a good deal with the character of the individual tree. In general, logs are cut to about 14 inches at the small end, though occasionally they may be cut as small as 10 inches.

From what has been said it may be judged that the lumberman is beginning to realize the necessity of logging as closely as possible. How close he may log must depend on his particular operation and the attending conditions. Since these conditions vary greatly, it is natural that the economy of logging operations should also differ widely. Most of the large concerns are now hauling to their mills sugar pine logs that have been lying on the ground thirty or forty years. The sapwood of these logs has of course rotted away, but the heartwood is usually as sound as on the day the trees were cut. One big lumber company is cutting its tops and limbs into firewood, which it handles at a small profit per cord. This it is enabled to do by the

existence of a good market near at hand, with which it is connected by its own railroad.

At least one company has reduced its loss in the fire-scarred butts of sugar pine to a minimum, for it cuts the butt log as though the fire scar did not exist, hauls it to the mill, and, as far as possible, cuts it into full-length boards. What is left is then cut into "shorts."

All this shows a marked change in the lumberman's attitude. The change has doubtless been brought about largely by the great increase in the amount of capital that under modern methods must be invested in a lumber plant. This fact makes it business policy to use every stick of timber possible in order that the relative cost of logging may be reduced. This policy is in some instances carried so far that timber is taken out which by itself represents an actual loss per thousand feet, but which, taken in connection with the operation as a whole, means actual gain by reducing the cost per thousand feet of logging.

To bring about any closer utilization than already exists is therefore not to be expected directly from the lumberman. Further improvement must depend upon the market and upon the reduced cost of transportation.

In the actual cost of lumbering operations there is a wide variation, due largely to the difference that exists in the accessibility of the timber. Exclusive of stumpage price, it probably costs on the average about $9 per thousand feet from the stump to placing rough lumber f. o. b. the Southern Pacific Railroad in California. This figure allows only for actual cost and does not include the charge per thousand feet for sinking fund, interest on investment, insurance, etc.

Where fluming is employed the yearly cost of maintenance is charged against this item. A more itemized statement of the cost of lumbering follows:

	Per thousand B. M.
Average cost of logs at mill	$5.00
Average cost of milling	2.00
Fluming or railroading to Southern Pacific Railroad	1.00
Cost each time lumber is handled	.50
Total	8.50

The actual logging is the most variable item, and upon it the total cost largely depends. It varies from $3 to as high as $8 per thousand feet. Milling is somewhat high, but includes here the whole operation from putting logs in pond to taking out the lumber at the other end.

If all costs that are charged against the lumber, such as taxes, sinking fund, insurance, etc., be reckoned, it is probable that few companies can place lumber on the railroad for less than $14 per thousand, and that it often costs as high as $16 or more. When it is considered that the average price for all lumber f. o. b. is $17 per thousand, it will be seen that the margin of profit is often very small.

EFFECT OF LUMBERING UPON THE FOREST.

To judge correctly of the real effect of present lumbering methods upon the forest is almost impossible, since these methods have been in use but a short time. Some idea of the effect of lumbering may usually be gained from lands logged in the past under methods which closely approximate those of the present.

The most striking effect of lumbering is that it changes entirely the character of the forest; in other words, it upsets the balance between species that existed in the virgin stand. Generally three conditions prevail after lumbering. The first and the least common is that usually found on steep rocky slopes where the cutting has been clear. In such places the erosion is great, especially after the humus and litter have been destroyed by fire, and seed obtains very little foothold and is easily washed away. The result is an entire absence of young growth, or at best a very scattered stand. A second condition is where the chaparral, with the assistance of fire, is let in after lumbering and supplants the forest growth. This is common only in certain regions, such as southern California, where the chaparral is very prevalent. The third condition is where a good reproduction follows. The most noticeable thing on areas that have been cut clear is the great preponderance of young yellow pine over other species, even in places where yellow pine formed a relatively small part of the original stand. An admirable example of this is to be found in Butte County on an area logged over about twenty years ago. The original cutting was not very heavy, but it was followed by a very severe fire which killed most of the standing trees. Enough, however, were left to furnish seeds. These seed trees were yellow pine, sugar pine, Douglas spruce, and cedar in about equal numbers, sugar pine being somewhat in the minority. At present this area is covered with a splendid growth of young trees, chiefly yellow pine with a scattering of other species. Cedar is next in abundance, but is rapidly being overtopped and crowded out. Since the conditions are those that particularly favor yellow pine, the future stand will undoubtedly be a nearly pure one of this species, with here and there a spruce or sugar pine and a scattered understory of more or less suppressed cedar. In the culled forest, where a partial cutting was made twenty or thirty years ago, different conditions exist. Seed trees of Douglas spruce and cedar are more abundant than the pines, and the partial shade does not favor yellow pine. Thus the reproduction is often to a large extent cedar and spruce, with a good representation of yellow pine and often of sugar pine also. In short, the young stand more nearly resembles the original stand than on clear-cut areas.

The most far-reaching effect of lumbering, however, has been its relation to fire. Lumbered areas, owing to the brush and slash upon

them, have offered particularly favorable conditions for severe fires. So great is the danger that fire almost invariably follows lumbering, and to it many of the after effects of lumbering, such as the presence of chaparral, the entire absence of young growth, etc., may be traced. The worst feature, perhaps, of such fires is the destruction of standing trees which might otherwise serve to seed up the area. In other words, to insure reproduction after lumbering, often all that is necessary is to keep out fire.

MANAGEMENT.

ADVISABILITY OF CONSERVATIVE LUMBERING.

Conservative lumbering for the private timberland owner is dependent upon questions of profit and loss, and all factors that have any bearing upon the financial situation will influence the method of managing the forest. Perhaps the most important factor in this respect is stumpage values, for it may be taken almost as a maxim that low stumpage values are conducive to poor management, while high stumpage values mean at least the possibility of good management or the better management of forest lands.

If stumpage values are low, the utilization of the timber crop must be incomplete and the logging methods wasteful. Although the tree as it stands in the forest has little value in itself, the lumberman cuts it, because it yields him a profit, and a tree or part of a tree that will yield little or no profit in its manufacture and has no value in itself will hardly be taken from the woods. In brief, the tree as a tree is of little value, and what is of little value will never be carefully used. As a corollary of this, when the timber crop in itself is of small value it will not pay to expend much on its protection or in securing a future crop; but as soon as the forest itself becomes of value and injury to it means actual loss, it becomes worth while to expend a certain amount as an insurance against such loss and for the continuance of the supply.

Stumpage values in California have just reached the stage where the timber is of really recognized value. Formerly timberland was bought and sold at so much per acre, and the price bore very little relation to the amount of timber on the land. Then there began to be a definite relation between the two, until at present in most localities the chief species at least have a recognized stumpage value per thousand feet. This varies from $1 to $2 per thousand feet for sugar pine, slightly less for yellow pine, and still less for fir, spruce, and cedar. In one region, where much of the timber has already been cut and stumpage is high, the following scale exists: Sugar pine, $1.75 per thousand; yellow pine, $1.50 per thousand, and white fir, 75 cents to $1 per thousand. One concern has paid $1 lump stumpage for timber on land previously culled. On the Federal reserves $2 per thousand has been fixed as a minimum price for pine stumpage. Outside of a few

localities where timber is scarce, such as the San Jacinto Mountains, this is the highest price so far obtained in the State, and is an indication of the higher trend of stumpage values.

Within the past few years the rise in stumpage values has been rapid, but this is largely because merchantable timberland has become less available for purchase. In the future, however, the stumpage price must depend upon other factors. These are the total supply of timber, and the market. The price of stumpage can not exceed the difference between the price of rough lumber and the cost of manufacture, plus a reasonable profit. To a certain extent the market price is governed by supply—that is, the supply in California—but since the California timber comes in competition with timber from other regions, the price of lumber, irrespective of supply, can not rise above a certain point. But as the market for western timber improves, as it seems certain to do, the price of stumpage will rise. However that may be, stumpage values have already reached a stage where they have ceased to be the chief obstacle to better management of the forests.

Another important financial factor in the management of forest lands is taxes. High taxes and high assessment values, by forcing the lumberman to denude his land as quickly as possible and to part with it after he has stripped it, stand in the way of conservative management. As a general rule taxes are not as high in California as in many States. They vary in different localities, however, and in many are undoubtedly excessive. The tax rate varies from 15 to 30 mills on the dollar. Timberland is assessed at from $5 to $10 per acre, and in one or two instances as high as $12, while cut-over stump land, as it is termed, varies from $1 to $2.50. It is with the cut-over land that the abuse lies. After the lumber is cut the land is often worthless. Where it has any market value at all, this seldom is as high as $1.25 per acre.

Naturally the private lumberman will not hold land for a second crop or make any effort to secure one, when for years to come he will have to pay taxes on it, although it yields no revenue. It must not be overlooked, however, that in spite of this fact there has been very little cut-over land turned back to the State. There are several reasons for this. Lumbering in the State is still in its youth, and sufficient time has not yet elapsed for cut-over land to collect on the lumbermen's hands to a burdensome extent, especially as on the lands first logged the cutting was in many instances light, and these lands are to-day being profitably relogged. Again, the existence of the lieu-land law made it possible to practically exchange cut-over land for virgin timber. A third reason exists in the increasing unwillingness of the lumberman, as he comes more and more to appreciate that his land may have a future value, to part with it in this way.

ADAPTABILITY OF THE SPECIES TO MANAGEMENT.

The chief factors which determine the form of management for a given species are: (1) Its commercial value or importance as a timber tree; (2) its rapidity of growth; (3) the possibility of securing a second crop.

SUGAR PINE.

Sugar pine is at present the most valuable timber tree of the Sierra forest. The wood has a wide and increasing variety of uses, and is largely sought as a substitute for eastern white pine. The rate of growth under present conditions is fairly rapid, and it is believed that under proper management this rate would show a large increase.

Sugar pine nowhere grows in pure stands, and this fact, coupled with the large number of diameter classes always present in the virgin forest, made it impossible to secure figures upon which to base an accurate estimate of future yield. All observations, however, tend to the belief that, when the certain rise in stumpage prices is considered, the future yield of sugar pine will be sufficient to justify conservative methods.

The greatest drawback to the efficient management of sugar pine is the difficulty of securing a second crop. The tree's restricted range, its intolerance, the irregularity of its seeding, and the lack of proper seed beds will seriously retard any attempt to secure its presence in the future stand. In the light of its importance as a timber tree, however, it is believed worth while to do all that is practicable to secure its continued supply.

YELLOW PINE.

Yellow pine, though not so valuable commercially as sugar pine, is yearly increasing in importance as a timber tree. Its rate of growth, especially for a short rotation, exceeds that of sugar pine, and its silvical characteristics make it readily adaptable to management.

FIRE PROTECTION.

The initial step to any practical system of managing the sugar and western yellow pine forests of California must of necessity be an adequate and effective plan for protection against fire. To remedy the existing conditions, two methods present themselves. The first, which is general and lies largely within the province of the State, consists in the establishment and proper enforcement of good fire laws and in the education of the public to a realization of the damage caused by forest fires. The second, which is more specific and lies within the province of this report, is the formulation of definite plans of fire protection for definite timber tracts, whether public or private. The recommendations which follow must have a somewhat general

character, since local conditions upon each timber tract largely determine the details of a plan.

The first step toward protection from fire should be the burning of "slash" on lumbered areas as soon as possible after lumbering takes place. Material left on the ground, in the shape of tops or limbs, soon becomes extremely inflammable, and is almost certain to burn sooner or later. The wisest course, therefore, is to burn this débris while means of control are available and before an opportunity for the accidental starting of a fire which, in addition to killing all growth left on the lumbered area, may spread to adjacent timber. Slash should be burned either in the late fall, just after the first rain, or in the spring, just before the beginning of the dry season. For successful burning the slash should not be too wet to be thoroughly consumed, although the ground should be moist enough to prevent the fire from spreading beyond control.

From the few available figures on the cost of slash burning it is believed that, if properly handled, slash can be burned without piling at an average cost of 25 cents per acre, and in many cases for less. On a tract of 50,000 acres where 1,000 acres are cut annually, slash burning would add one-half a cent per acre to the cost of protection. If it is necessary to pile the slash, the cost of burning might reach 25 cents per thousand feet of timber cut.

In addition to slash burning, a good system of patrol is usually advisable. By constantly patrolling a tract during the danger season fires may be detected at the outset and extinguished before they become unmanageable or do much damage. The amount of territory that can be patrolled by one man varies with the general topography of the tract in question and the accessibility of the parts of it by road or trail. Where there is a good system of roads and trails, one man should easily cover 40,000 acres. The hire of a patrolman and the keep of his horse for six months, during the danger season, should not exceed $75 per month, or $450 for the season, bringing this part of the cost of protection to 1¼ cents per acre.

The efficiency of a patrol system would be greatly increased if a system of telephone lines connecting the different parts of a timber tract with headquarters were installed, thus enabling the patrol to quickly report fires and to summon aid when necessary. Tool houses at convenient points, with tools for fire fighting, are also desirable.

Where the danger from fire is unusually great, it might be advisable, when building roads and trails, to run them with a view to their acting as fire lines. To this end all existing roads and trails should be kept free of litter, that they may not only serve as bases for back firing, but also act as barriers to the spread of ground fires.

METHODS OF MANAGEMENT FOR PRIVATE LUMBERMEN.

The lands now held by lumbermen may be classed as either cut over or virgin. The cut-over lands are of two classes—those on which young growth is coming in, and those which, through frequent fires or other cause, are practically without tree growth of any kind. Virgin lands include those which have never been cut over and those which were culled many years ago, but still bear a good stand.

On the first class of cut-over lands to secure a future crop it is only necessary to keep fire out. In the second class nothing can at present be done. These are virtually waste lands.

On the virgin lands management is altogether a question of lumbering and protection. Any modifications of present methods, moreover, must be of a simple nature. That it is practicable to improve them is shown by the logging on the forest reserves and by the fact that several large lumber companies in California have already applied conservative lumbering in the management of their lands.

The point has now been reached when timberland can not readily be obtained. Lumber companies with large investments in mills, railroads, and flumes must in future rely largely upon the lands they already own for a supply of timber sufficient to keep their plants in operation. Under existing methods the supply on many timber tracts will last no longer than fifteen or twenty years, and measures which will lengthen this period should be worthy of the lumberman's consideration.

In addition to protecting his land from fire, the private lumberman should provide for a future crop on his lands while cutting the present one. To do this, he must leave trees to furnish seed, and, in some instances, to protect the soil, and during the logging operations he must avoid injuring, as far as possible, the trees left standing. These trees, if well selected, will serve the double purpose of establishing young growth and, in ten, fifteen, or twenty years, of furnishing a second cut. To leave a sufficient stand of seed trees for both purposes the diameter limit to which the original stand is cut would seldom be less than 20 inches, and in many instances it would be necessary to place it much higher. Even when a diameter limit has been decided upon, it may often be advisable to leave some seed trees which are above the limit or to cut some which are below it, to insure their even distribution or to remove defective trees.

Tables III and VI show that if the stand is cut to a diameter limit of 18 inches three yellow and one sugar pine over 12 inches in diameter will remain on each acre, while if it is cut to 24 inches six yellow and two sugar pines will be left. Tables VII and VIII show that if the stand is cut to a diameter limit of 30 inches four sugar pines in both instances and in one case five yellow pines and in the other seven will be left. The tables apply to specific localities, and show only the

results of cutting to a diameter limit on these areas. Elsewhere the number of trees left might be greater.

Cutting to a diameter limit of 30 inches will often leave a sufficient stand to warrant a second cut as soon as reproduction is established. Table VIII shows, for example, that the average diameter of the trees left would be about 22 inches and the stand per acre approximately 5,400 board feet. This amount may not, at present, warrant a second cut. In fifteen or twenty years, however, through increased growth and the probability of smaller sizes being merchantable, the possible cut will be much larger.

Present lumbering in California, since it often approaches clear cutting, favors the reproduction of yellow pine, while it retards that of sugar pine. All that is necessary to secure an abundant reproduction of yellow pine is to reserve a few seed trees and to keep fire out. Sugar pine, on the other hand, requires a certain amount of shade when very young, and if this is lacking, the seedlings die. While it will be difficult to secure an abundant second crop of this species, if enough seed trees of sugar pine are left to form the basis of a second crop the partial shade and the abundance of seed will be favorable to its reproduction.

Since the forests in which sugar and yellow pine occur vary greatly in composition, the method of treatment must also vary. For this the forest types already distinguished may form a basis.

On the lower portion of the sugar pine-yellow pine type, where sugar pine forms but a small proportion of the stand, only the yellow pine should be considered for the future forest. All merchantable sugar pine may therefore be removed. It will be necessary to leave only a few seed trees of yellow pine to restock the ground, although usually it will be a wiser policy to leave a fair stand, since this can be removed as a second cutting when reproduction is established. This procedure would also hold for areas on which yellow pine occurs in nearly pure stands. In these localities dense stands of second-growth yellow pine occur. It will often be profitable, where there is a market at hand, to thin these stands when they are about 30 years old, removing the suppressed trees for mine props. Trees 6, 8, and 10 inches and up are used for this purpose, and sell for from 5 to 6 cents a running foot.

On the upper portion of the sugar pine-yellow pine type, where both species have about an equal representation in the stand, seed trees of each should be left, wherever practicable, in the proportion of two sugar pines to one yellow pine.

In the fir belt, where sugar pine and fir are the principal species, the fir should be cut clean wherever possible, and sugar pine should be relied upon for the future forest.

On all lands the Douglas spruce, white fir, and incense cedar should be cut whenever possible, and chutes, skidways, and bridges should be constructed from the two last-named species.

The scheme for fire protection has already been outlined, but its importance merits definite rules for protecting lands which are being logged. These are included in the following rules for lumbering:

1. Slash should be burned after cutting, either in the following fall after the first rains or in the spring immediately after the last rains.

2. In burning slash, trees left standing should be protected from fire by piling the brush and débris as far from their bases as possible.

3. Considerable areas of young growth already existing on the ground should be protected during slash burning by back firing from the border of such areas. It will often prove impracticable to protect scattered clumps of young growth.

4. The tract as a whole should be protected from fire by a patrol, and in some instances by fire lines.

5. On the sugar pine-yellow pine type all sugar pine trees too small to be valuable for timber should be left and care taken to protect them during logging. At least two yellow pine trees should be left to the acre.

6. All other species besides yellow and sugar pine should be cut if at all merchantable, and should be used for constructing bridges, chutes, skidways, etc.

7. On the fir type all unmerchantable sugar pine should be left standing and protected. All white fir that can be used should be cut.

8. All trees to be cut should be plainly marked.

MANAGEMENT ON FOREST RESERVES.

Lumbering on the Federal forest reserves will undoubtedly be capable of greater variation in method than the lumbering of private owners, since the Government can better afford to leave its capital for a long time in the form of merchantable trees left standing. On the other hand, the Government does not log the timber itself, but sells it to private lumber companies, and this fact must always regulate, to a greater or less degree, the methods of lumbering employed. The restrictions placed upon the purchaser of reserve timber should therefore be in the highest degree practical, and such as will enable him to realize a fair profit on his purchase.

The timber on detached holdings should be sold, since most of it is mature or overmature and will deteriorate in quality if held too long.

On lands of the sugar pine-yellow pine type, included within the reserves, no trees of these two species are cut under 17 inches in diameter, and often the limit is 24 or 30 inches. If cutting to the fixed diameter limit does not insure a sufficient stand for a second cut, a sufficient number of trees above the limit are left. Trees are cut to 10 inches diameter in the tops, but because of crooked or forked tops a considerable leeway is permitted in this regulation. Stumps are cut 18 inches high on the uphill side and 24 inches on the downhill side, but allow-

ance is made for swelled butts, fire scars, etc. Charred trees, particularly sugar pine, are not long butted, except in extreme cases, but in scaling the butt logs from such trees a liberal allowance is made for cull. The bases of trees left are, wherever possible, cleared of brush and other débris, and the trees are protected from injury during logging operations. After logging, a space is cleared around those trees which have débris within 30 feet of their bases.

If trees are felled with their tops together the labor of piling is greatly decreased, and it is possible to perform the whole operation at a cost of not more than 25 cents per 1,000 feet of timber cut.

CONCLUSION.

From the preceding study it is plain that conservative management of the sugar and yellow pine forests of California is practicable. The greatest obstacle to securing a future crop of timber is fire, but it is believed that effective fire protection is possible, and at a reasonable cost. With this accomplished and with a sufficient number of seed trees left after lumbering, the ground will soon become stocked with young growth.

Since this report was written the city of San Francisco has been almost entirely destroyed by earthquake and fire. What effect this will have on the local lumber market it is yet too early definitely to say. There is little doubt, however, that any increased demand will chiefly affect redwood and Washington and Oregon fir, whereas the market for sugar pine and yellow pine will not be affected sufficiently to modify or make incorrect any of the statements or conclusions made in this report.

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